In the Specification:

Please replace the paragraph beginning on page 7, line 14, with the following rewritten paragraph:

A1

--A preferred composite media includes a periodic array of conducting elements that can behave as a continuous medium for electromagnetic scattering when the wavelength is sufficiently longer than both the element dimension and lattice. The preferred composite medium has an effective permittivity $\varepsilon_{eff}(\omega)$ and an effective permeability $\mu_{eff}(\omega)$ which are simultaneously negative over a common band of frequencies.--

Please replace the paragraph beginning on page 8, line 12, with the following rewritten paragraph:

A2

--FIG. 5(b) illustrates a single unit structure for an alternate embodiment of the invention;--

Please replace the paragraph beginning on page 8, line 14, with the following rewritten paragraph:

A3

--FIG. 6 illustrates a "G" resonator;--

Please add the following new paragraphs beginning on page 8, line 15:

A4

--FIG. 7 illustrates one periodic "swiss roll" resonator structure; and

FIG. 8 illustrates one periodic spiral resonator structure.--

Please replace the paragraph beginning on page 11, line 9, with the following rewritten paragraph:

--Because of the difficulties associated with inherently magnetic media, it is convenient to utilize non-magnetic media to achieve an effective magnetic response. Structures in which local currents are generated that flow so as to produce *solenoidal* currents in response to applied electromagnetic fields, can produce the same response as would occur in magnetic media, but at much higher frequencies. Generally, any element that includes a non-continuous conducting path nearly enclosing a finite area, and further introduces capacitance into the circuit by some means, will have solenoidal currents induced when a time-varying magnetic field is applied parallel to the axis of the circuit. We term such an element a *solenoidal resonator*, as such an element will possess at least one resonance at a frequency ω_{m0} determined by the introduced capacitance and the inductance associated with the current path. Solenoidal currents are responsible for the responding magnetic fields, and thus solenoidal resonators are equivalent to magnetic scatterers. A simple example of a solenoidal resonator is ring of wire, broken at some point so that the two ends come close but do not touch, and in which capacitance has been increased by extending the ends to resemble a parallel plate capacitor. A composite

A5 cont'd

medium composed of solenoidal resonators, spaced closely so that the resonators couple magnetically, exhibits an effective permeability. Such a composite medium was described in the text by I. S. Schelkunoff and H. T. Friis, *Antennas: Theory and Practice*, Ed. S. Sokolnikoff (John Wiley & Sons, New York, 1952), in which the generic form of the permeability (in the absence of resistive losses) was derived as--

A5 end

Please replace the paragraph beginning on page 16, line 11, with the following rewritten paragraph:

--In one preferred embodiment, the electric and magnetic units are periodically distributed, although within each unit the effective permittivity or permeability may be anisotropic, resulting in a medium in which the left-handed frequency band occurs only for one or two propagation directions. The spatial distributions of the units may include fractal, pseudorandom, random, or many other types. Either one or both of the negative permeability and negative permittivity media used in the composite medium of the invention may be modulated via external or internal stimulus. Thus, the composite medium may be switched between left-handed and right-handed properties, or between transparent (left-handed) and opaque (non-propagating) over at least one band of frequencies. Such switching is the extreme case, with lesser modulations to change values of permittivity or permeability within the positive and negative range also being useful. Another possibility is the use of a substrate which

A6 cont'd

responds to external or internal stimulus. A substrate that includes a piezoelectric material may serve to modulate the physical size of the substrate by a locally applied electric field. A substrate or element component incorporating magnetostrictive material may serve also to modulate the physical size of the substrate by an applied magnetic field. Additionally, the medium or a portion thereof may contain other media that have medium electromagnetic parameters that can be modulated. For example, a portion of the medium may be modulated by diverse resonance excitation such as NMR ("Nuclear Magnetic Resonance"), EPR ("Electron Paramagnetic Resonance"), CESR (:Conduction Electron Spin Resonance"), AFR ("Adiabatic Fountain Resonance"), FMR ("Functional Magnetic Resonance"), and paraelectric resonance. Additionally, media used may be photomodulated. The frequency position, bandwidth, and other properties of the left-handed propagation band can then be altered, for example, by an applied field or other stimulus.--

A6 end

Please replace the paragraph beginning on page 21, line 2, with the following rewritten paragraph:

--Here, ρ is the resistance per unit length of the rings measured around the circumference, ω is the frequency of incident radiation, ℓ is the distance between layers, r is the radial dimension indicated in FIG. 2(a), a is the distance in the lattice from one ring to the next in the planar direction, F is the fractional area of the unit cell occupied by the interior of the

A7 cont'd

A7 end

split ring, Γ is the dissipation factor, and C is the capacitance associated with the gaps between the rings. The expressions for ω_0 and Γ can be found by comparing the terms in Equation 5. Since the Q-factor of an individual SRR used in the experiments was measured to be greater than 600. Thus, effects due to damping are relatively small.--

Please replace the paragraph beginning on page 22, line 1, with the following rewritten paragraph:

A8 cont'd

--Using MAFIA (MAFIA is a trademark of Computer Simulation Technologies of America, Inc., Wellesley Hills, MA) Release 4.0, a commercial finite-difference code, dispersion curves were generated for the periodic infinite metallic structure consisting of the split ring resonators of FIG. 1. The dispersion curves are shown in FIGs. 3(a)-3(d). There are two incident polarizations of interest: magnetic field polarized along the split ring axes ($H_{\parallel}$, FIG. 3(a) inset), and perpendicular to the split ring axes ($H_{\perp}$, FIG.3(b) inset). In both cases, the electric field is in the plane of the rings. As shown by the curves in FIGs. (3)a and 3(b), a band gap is found in either case, although the $H_{\parallel}$ gap of FIG. 3(a) can be interpreted as being due to negative $\mu_{eff}(\omega)$, and the $H_{\perp}$ gap of FIG. 3(b) can be interpreted as being due to a negative $\varepsilon_{eff}(\omega)$. The negative permeability region for the $H_{\parallel}$ modes begins at 4.2 GHz and ends at 4.6 GHz,

spanning a band of about 400 MHz. Not evident from the FIG. 3(b), but consistent with the model indicated in Equation 5, $\mu_{eff}(\omega)$ switches to a large negative value at the lower band edge, decreasing in magnitude (but still negative) for increasing frequency through the gap. At the upper band edge, $\mu_{eff}(\omega) = 0$, and a longitudinal mode exists (not shown), identified as the magnetic plasmon mode by Pendry et al. For the dielectric gap shown in FIG. 3(b), the same behavior is observed, but with the roles of $\varepsilon_{eff}(\omega)$ and $\mu_{eff}(\omega)$ reversed.--

A8 end

Please replace the paragraph beginning on page 24, line 5, with the following rewritten paragraph:

--where ω is incident frequency, ω_p is plasma frequency, ω_b is greater than ω_0, and ω_b and ω_0 define endpoints of a typical left handed propogation frequency band. Equation (6) shows that the range of the propagation band (k real) extends from ω_0 to $\omega_b = \omega_0 / \sqrt{1-F}$. This was formerly the region of the gap of the SRR structure in the absence of the posts. The dispersion relation leads to a band with negative group velocity throughout, and a bandwidth that is independent of the plasma frequency for the condition $\omega_p > \omega_b$.--

A9

Please replace the equation beginning on page 24, line 22, with the following rewritten equation:

a10

$$k^2 = \frac{(\omega^2 - \omega_p^2)(\omega^2 - \omega_{2f})}{c^2(\omega^2 - \omega_b^2)} \qquad (7)$$

Please replace the paragraph beginning on page 25, line 22, with the following rewritten paragraph:

a11

--For the $H_{\|}$ polarization, 17 rows of SRRs were utilized in the H direction, (8 elements deep in the propagation direction) oriented as in FIG. 3(a) (inset). FIG. 4 shows the results of transmission experiments on split rings alone (solid curve), and split rings with posts placed uniformly between (dashed curve). The square array of metal posts alone had a cutoff frequency of 12 GHz; the region of negative permittivity below this frequency, where the medium was opaque, attenuated the transmitted power to below the noise floor of the microwave detector (–52 dBm). When the SRR medium was added to the wire array, a pass band occurred, consistent with the propagation region indicated by the simulation (FIG. 3(c)).--